The Next 40 Years:
The Challenge of Feeding 9.6 Billion

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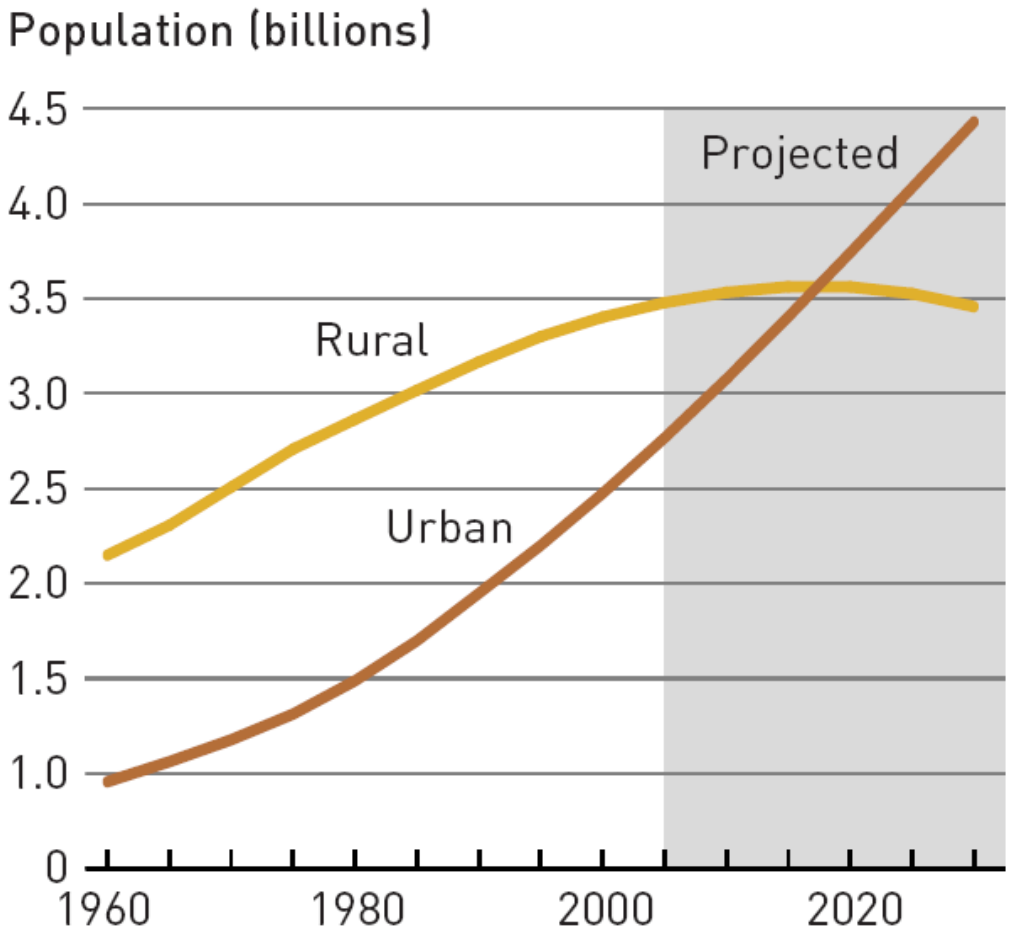
Projected Population Growth

Region	2012	2050	Change	Percent
World	7,058	9,624	+2,566	+ 36
High Income	1,243	1,338	+ 95	+ 8
Low Income	5,814	8,286	+2,472	+ 43
East & S.E. Asia	2,193	2,317	+ 124	+ 6
South Central Asia	1,823	2,565	+ 742	+ 41
Sub-Saharan Africa	902	2,092	+1,190	+132
Latin America/Carib	599	749	+ 150	+ 25
N. Africa & W. Asia	457	748	+ 291	+ 64

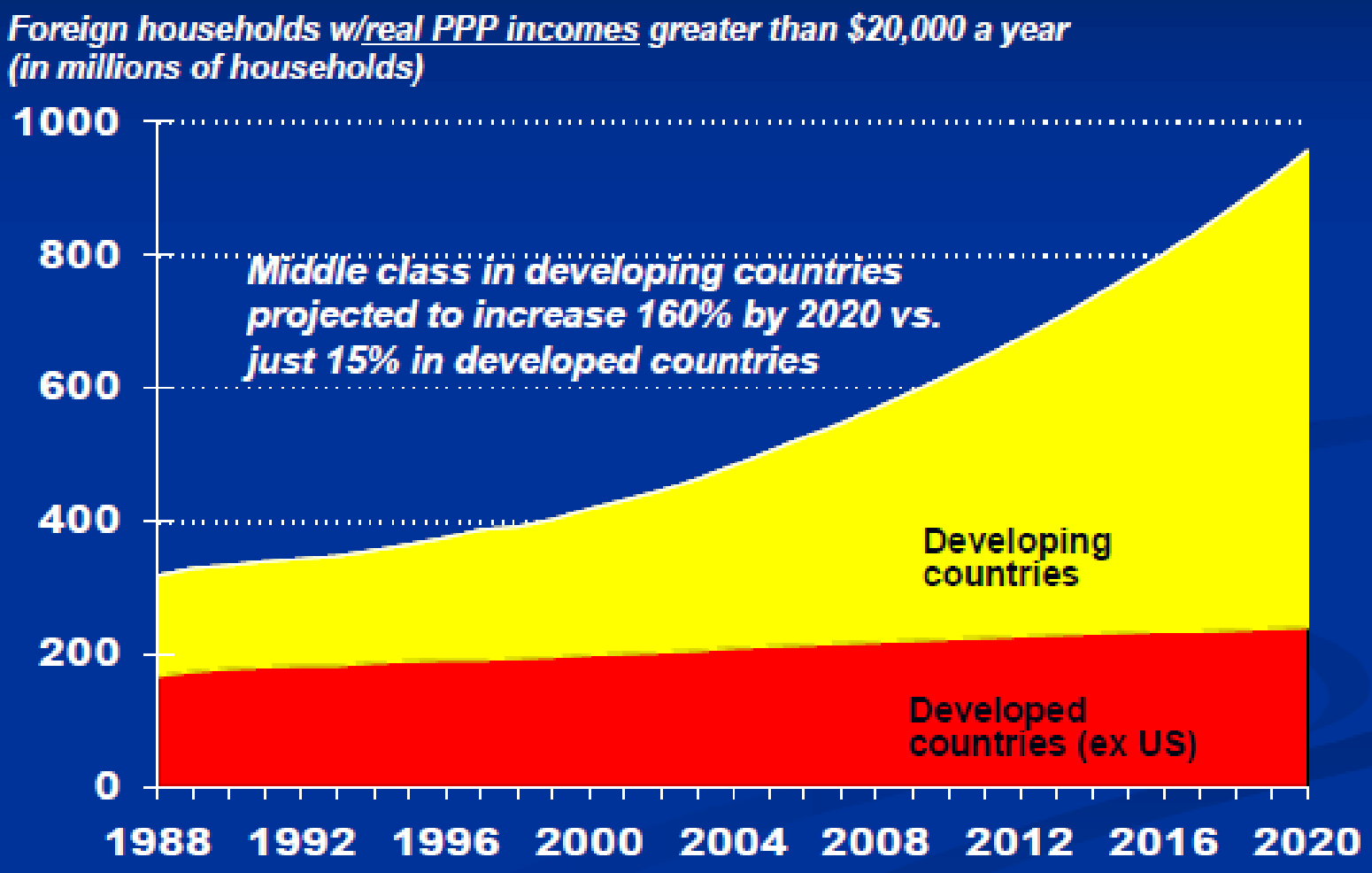
Source: Population Reference Bureau. 2012 World Population Data Sheet.

Urbanization in developing countries, 1960–2030



Source: UN

"Middle Class" *Outside the U.S.* Expected to Double By 2020 – Approaching 1 Billion Households



Source: Global Insight's Global Consumer Markets data as analyzed by OGA/FAS/USDA

Projected World Food Demand

- World food demand to grow 70-80% by 2050
  - 40% increase from world population growth – from 7.0 to 9.6 billion – almost all in developing countries
  - 30-40% increase from broad-based economic growth in low income countries
- The World Bank has estimated the number of people in developing countries in households with incomes >$16,000/year will rise from 352 million in 2000 to 2.1 billion by 2030.
- How many presently low income consumers escape from poverty is the *most important* uncertainty re future global demand for food.
- Policies that accelerate broad-based economic growth in LDCs reduce hunger, but unleash rapid growth in demand for agric. products.

The Land Constraint

- There is at most 12% more arable land available that isn't presently forested or subject to erosion or desertification on which to produce almost twice as much food..
  - And degradation of many soils continues.
- The area of land in farm production could be doubled…
  - But only by massive destruction of forests and loss of wildlife habitat, biodiversity and carbon sequestration capacity.
- The only environmentally sustainable alternative is to almost double productivity on the fertile, non-erodible soils already in crop production.

Water--A Growing Constraint

- Farmers account for 70% of the world's fresh water use.
- With the rapid urbanization underway, cities will outbid agriculture for available fresh water.
- The world's farmers, who are being called on to double food production, will have to do it using less fresh water than they are using today.
  - i.e., they will have to more than double the "crop per drop," the average productivity of the water they use.
- This will require investments in research to develop water saving technologies and to increase the drought tolerance and water use efficiency of the crop varieties being grown.

Sustainability Will Require Increased Global Food System Productivity

- Make presently unusable soils productive
- Increase genetic potential (of individual crops and/or farming system) (ditto for farm animals)
- Achieve as much of that potential as possible by:
  - Improving nutrition of that crop
  - Increasing water availability and efficiency of use
  - Reducing competition from weeds for water, nutrients and sunlight
  - Reducing losses from disease and insects
- Reduce post-harvest losses
- All these will require more agricultural research.

Climate Change Adds a Further Challenge

- Greater expected temperature increase over land than over water and greatest at higher latitudes.
- Increased spatial distribution of precipitation
  - Largest reduction in subtropics
  - Largest increases in higher latitudes
  - Increase under monsoons
- Increased frequency of extreme events, such as droughts and flooding.
- All agro-ecosystems will be shifting, so, given the location specificity of many ag technologies, need more adaptive agricultural research just to sustain present productivity.

Agricultural Research Potential

- There remains more productivity enhancement potential from classical plant and animal breeding, especially with modern genomics, and genetic engineering opens new frontiers:, e.g.
  - Improve nutritional content of grains, etc.
  - Increase tolerance to drought, wetness, temperature, salt, aluminum toxicity, …. (to increase yields and/or planted area under adverse or variable conditions)
  - Internalize resistance to diseases; viruses
  - Reduce pesticide use, esp. insecticides
  - Herbicide-resistant varieties
  - Slow down product deterioration

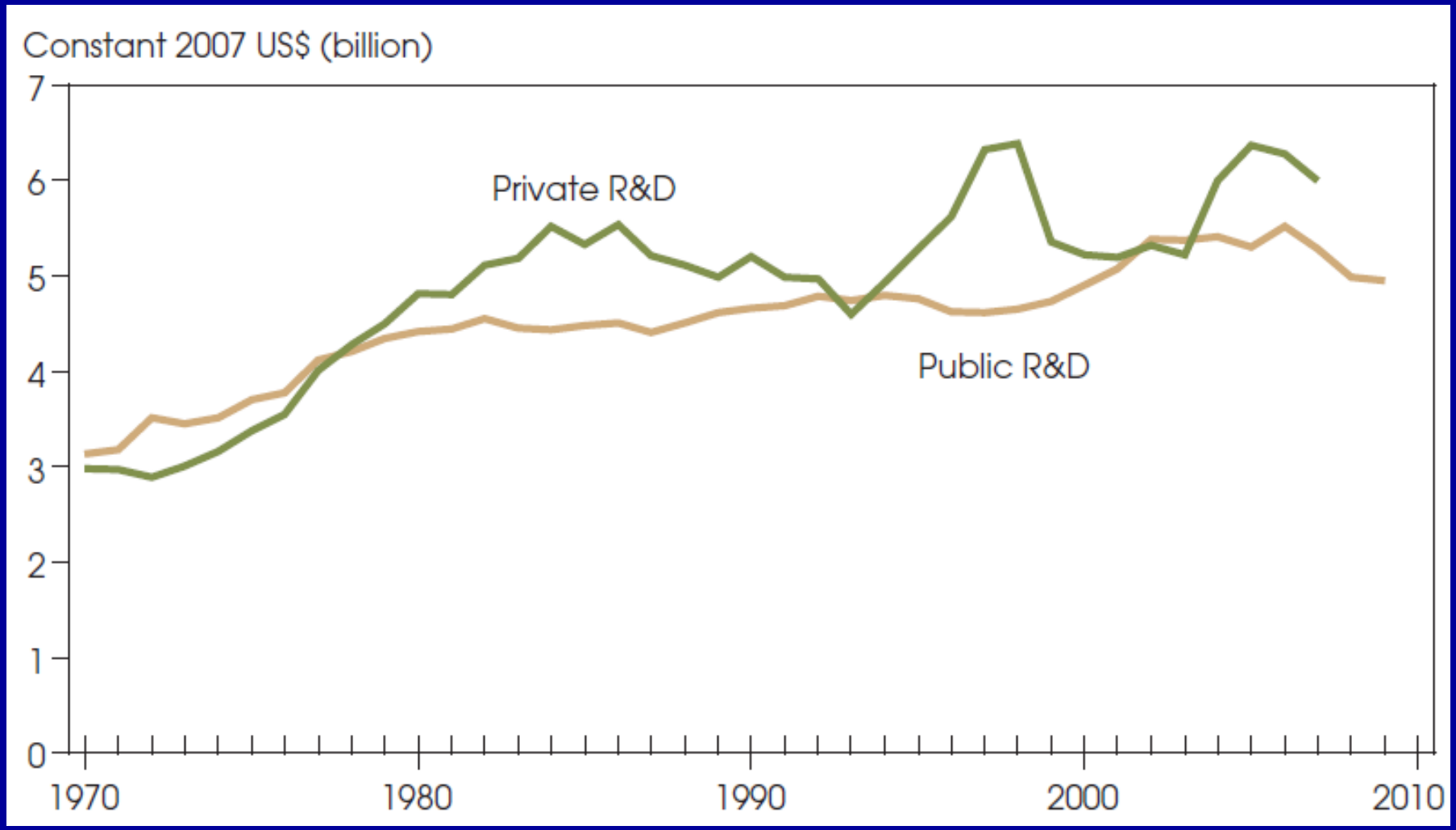
Agricultural Research Potential

- Low-till agriculture
- Precision agriculture
- Computers/data processing capacity
- Nanotechnology
- And many more areas of science

Need Both Public & Private Agricultural Research

- There are many areas of research in which the private sector will invest less than the social optimum, such as:
  - Basic research: Payoff is too uncertain and too far in the future
  - Where hard to protect intellectual property, e.g. open-pollinated varieties
  - Where no market exists, e.g. conservation and public policy
- Other reasons why public investment is needed as well as private:
  - No individual farm can capture all the benefits from research.
  - Scale of investment needed is large
  - Most of the benefits eventually accrue to consumers.
- Universities need to be involved in ag research since they are training the next generation of Ph.D. scientists.

Public vs. Private Investments in U.S. Ag Research



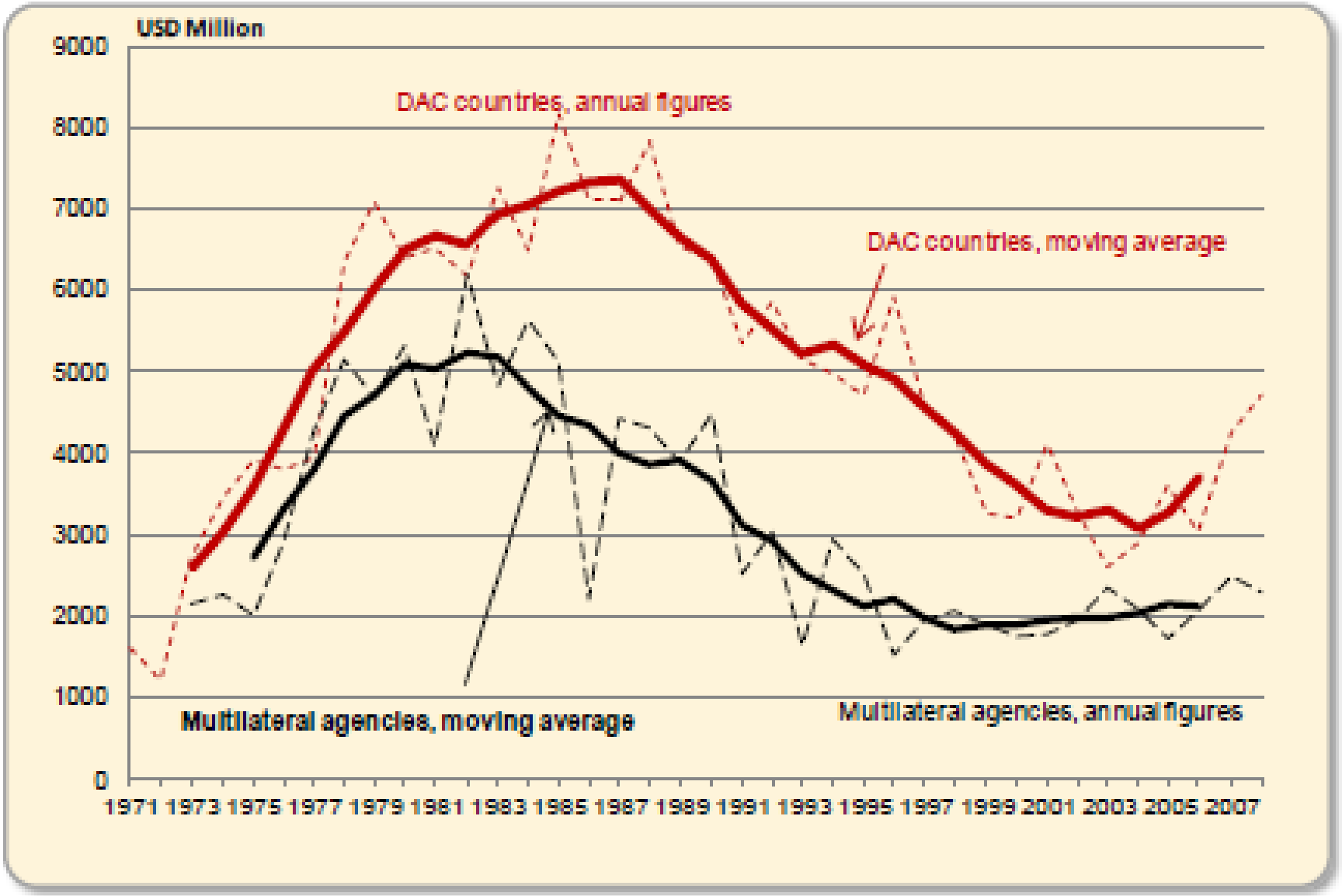
Source: Fuglie, ERS, USDA

Agriculture Has Been Off the Global Development Agenda

- Agricultural & rural development were priorities for foreign aid and international development bank lending up until the mid-1980s, but:
  - Between 1980 to 2005, foreign aid to low income countries for ag development dropped from $8 billion to $3.4 bill./yr (from 17 to 3% of the whole)
  - In the 1980s, 25% of U.S. foreign aid went to agriculture; dropped to 6% by 1990 and 1% by 2008.
  - Share of World Bank lending going to agriculture fell from 30% in 1978 to 16% in 1988 to 8% in 2006.
- **The share of foreign aid and development bank lending invested in agricultural research fell by an even larger percentage during this period.**

Chart 1. Trends in aid to agriculture

Commitments, 1973-2008, 5-year moving averages and annual figures, constant 2007 prices



Long-Run Prospects

- Since Malthus, prophets of doom have argued population growth will increase food demand faster than agricultural production can grow.
- Public and private sector investments in agricultural research have increased productivity faster than demand growth, with resulting 150-year downward trend in real price of grains.
- Need big increase in world food production by 2050 using less water and little more land than today and also produce biofuels feedstocks.
- Future world market price trends will depend on whether ag research increases land and water productivity faster than world demand grows.